Upper Ordovician Stratigraphy, Sedimentology, and Paleontology along Backbone Creek, Clermont County, Ohio

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INTRODUCTION

The Upper Ordovician, Cincinnatian Series is characterized by 250 m (820 ft) of generally undeformed, richly fossiliferous, interbedded carbonates (predominantly limestones) and calcareous siltstones and shales. The abundance of fossils, along with the quantity and quality of exposures has resulted in countless reports on Cincinnatian geology. Generally, the geologists contributing to this body of literature have studied a particular group of fossils (e.g. Bassler, 1906; Foerste, 1905, 1909, 1919; Hall, 1962; Pojeta, 1962; Thompson, 1970; Singh, 1979; Elias, 1983), or the stratigraphy of a specific region (e.g. Nickles, 1902; Foerste, 1903; Cumings, 1908; 1922; Fenneman, 1916; Brown and Lineback, 1966; Peck, 1966; Ford, 1967; Hatfield, 1968; Gray, 1972; Hay, 1981; Tobin, 1982), or mapped a small area with the Cincinnatian Series outcrop area (e.g. Ford, 1972, 1974; Gibbons, 1972; Kohut et al., 1973; Kohut and Weiss, 1981; Luft et al., 1973; Osborne, 1970, 1974; Osborne et al., 1973; and Outerbridge et al., 1973). In recent, years the trend has shifted to examining the Cincinnatian Series on a regional scale (e.g., Hay, 1981; Tobin, 1982).

County by county mapping of the state of Ohio as mandated by Amended House Bill 385 will be the most comprehensive study to date examining the Cincinnatian Series in Ohio. In the course of field investigation for Clermont County, the classic exposures produced by Backbone Creek were discovered (Fig. 1). These exposures provide excellent examples for discussion of the geology and current status of mapping of the Cincinnatian Series. Stops along our traverse will illustrate the stratigraphy being mapped, sedimentology, paleontology, paleoecology, bedrock geomorphology, the regional Upper Ordovician-Quaternary unconformity, and minor deformational features of this portion of the Cincinnatian Series.

Historically, formations in the Cincinnatian Series have been defined on the basis of stratigraphic ranges of diagnostic fossils (brachiopods and bryozoans) in conjunction with general lithologic descriptions (e.g. Orton, 1873; Nickles, 1902, 1903; Foerste, 1905, 1910; Bassler, 1906). Modern stratigraphic studies utilized the ratio of total siltstone and shale thickness to the total limestone thickness within a specific vertical interval (clastic ratio) to define stratigraphic units in compliance with the American Code of Stratigraphic Nomenclature (1961, Article 4, a lithologic definition of formations) (e.g. Weiss and Sweet, 1964; Peck, 1966; Ford, 1967; Osborne, 1968; Tobin, 1982).

Examining recent studies, it is apparent that two schools of thought have developed. The first approach rejects the older biostratigraphic nomenclature of Orton, Nickles, Foerste, and Bassler (see Davis, 1981; Fig. 2) in favor of thick, undifferentiated formations (e.g. Dillsboro, "unnamed beds", Bull Fork Formation; see Fig. 2). The second approach utilizes the older nomenclature but redefines unit boundaries on a lithologic basis (e.g., Ford, 1967; Tobin, 1982; Fig. 2).

The mapping philosophy of the Ohio Division of Geological Survey utilizes the valid older stratigraphic units with redefined lithologic boundaries and replaces invalid older units. The McMillan Formation defined by Bassler (1906) illustrates this type of substitution required in generating a mapping stratigraphy for the Cincinnatian Series. Bassler introduced the McMillan Formation in the Cincinnati area for mapping purposes, but never described a type section, formational boundaries, or mapped the formation's areal extent. The Stratigraphic Code requires a type section and formation boundaries to be described along with mapping the areal extent of the formation. On this basis the McMillan Formation is invalid. However, the Bellevue, Corryville, and Mt. Auburn Members of this formation (Fig. 2), with redefined boundaries, do adhere to the Stratigraphic Code. Therefore the present mappers were faced with three valid members of an invalid formation. The compromise was not to name a new formation, but instead to replace the McMillan Formation with the laterally contiguous Grant Lake Limestone (described from the Maysville, Kentucky area). Figure 3 presents the current stratigraphy being mapped by the Ohio Division of Geological Survey.

The composite stratigraphic section exposed along Backbone Creek is approximately 73 m (240 ft) thick and consists of three formations. In ascending order, the units are the Kope Formation, Fairview Formation, and Grant Lake Limestone (Bellevue and Corryville Members) (Fig. 4). Our traverse will begin in the Kope and end in the Bellevue.

DESCRIPTION OF EXPOSED STRATIGRAPHIC UNITS, BACKBONE CREEK

The Kope Formation consists of 75-80% thick, planar-bedded, medium bluish gray, generally unfossiliferous, platy-to-flaggy-weathering calcareous shales and 20-25% thin, planar-to-lenticular-bedded, medium gray to medium bluish gray, occasionally graded and rippled fossiliferous limestones (grainstones and packstones). Fossils include bryozoans, brachiopods, echinoderms, mollusks (bivalves, gastropods, and cephalopods), arthropods (trilobites and ostracods), conodonts, graptolites, scolecodonts, tentaculitids, and various minor elements. Limestones and shales weather to medium bluish gray to brownish yellow. Contact with the overlying Fairview is sharp and placed at the base of the first closely-spaced limestones of the Fairview. Approximately 30 m (100 ft) of the Kope is exposed along the Backbone Creek composite section.

The Fairview is composed of 50% thin, medium gray to medium blue-gray, planar to lenticular, occasionally graded and rippled limestones (grainstones, packstones, and wackestones), and 50% medium gray to medium blue-gray, planar to lenticular, calcareous silstones and shales. Calcareous siltstones are generally thin and cross-laminated with erosional bases and the shales weather platy to flaggy. Limestones, siltstones, and shales weather from medium bluish gray to brownish yellow. The contact with the overlying Grant Lake is gradational and is placed arbitrarily within the interval of change from planar, continuous limestones and platy to flaggy shales of the Fairview and the wavy-bedded, discontinuous limestones and fissile bioclastic shales of the Bellevue Member of the Grant Lake. The thickness of the Fairview is 30 m (100 ft).

The Grant Lake Limestone (Bellevue Member) is characterized by 70-75% thin, medium gray to medium blue-gray, wavy-bedded, discontinuous limestones (grainstones and packstones) and 25-30% thin, medium gray to medium blue-gray, bioclastic, fissile shales. The Bellevue weathers to a distinctive rubbly float readily noticed in stream alluvium. The contact with the overlying Corryville is exposed in Backbone Creek but will not be examined because of time constraints. The Bellevue is 8 m (25 ft) thick.

SEDIMENTOLOGY

The alternation of limestone and shale is the single-most diagnostic feature of the Cincinnatian Series. The origin of this alternation of limestone and shale has been debated for over 80 years. The result has been the recognition of three types of sedimentary cycles based on the repetition of individual beds of specific lithologies (e.g. limestone and shale), the alternation of packages of similar lithologies, and the recurrence of similar lithologic sequences throughout the Cincinnatian Series (Tobin, 1982).

Cincinnatian sedimentary cycles will be termed storm cycles, megacycles, and shoaling-upward cycles following the usage of Tobin (1982). Storm cycles are generally less than 0.5 m in thickness and are recognized by the alternation of individual limestone or siltstone beds with individual shale beds. Storm cycles were produced by the action of storm-generated currents on benthic faunas and sediments (Kreisa, 1981; Tobin, 1982). Megacycles (0.4-4 m thick) are characterized by the alternation of a predominantly limestone package with a predominantly siltstone and shale package. Megacycles represent clear water sedimentation with abundant biological productivity (limestones) interrupted by terrigenous sedimentation. Tobin (1982) interpreted the terrigenous episodes as the result of climatic fluctuation or periodic shifting of point source areas (e.g. deltaic shifting, tectonics, or volcanic activity). Shoaling-upward cycles (40-200 m thick) are defined by the recurrence of lithologic sequences (formations or members) within the Cincinatian Series. These cycles represent deposition on an inclined slope of an offshore (Kope), transition (Fairview), and shoreface (Bellevue) sequence of facies as the result of major transgressions and regressions. (Anstey and Fowler, 1969; Meyer et al, 1981; Tobin, 1982) Figures 5, 6, and 7 are schematic representations of Cincinnatian Series sedimentary cycles.

We will observe examples of these sedimentary cycles on our traverse of Backbone Creek. The depositional and sedimentological history of the Cincinnatian will be outlined through our observation of the major characteristics of these sedimentary cycles.

PALEONTOLOGY AND PALEOECOLOGY

The Cincinnatian Series is famous worldwide for its abundant and well preserved fossil invertebrates. Numerous paleontologic studies have focused on particular Cincinnatian taxonomic groups but few have treated the entire fauna and its paleoecology. The common fossils occurring in the section are illustrated in Davis (1981). Up-to-date taxonomic studies on many Cincinnatian taxa can be found in Pojeta (1979). Information presented here will be limited to a brief summary of the fossil assemblages, preservational style, and certain trace fossils characteristic of the units to be seen at Backbone Creek. Major paleontologic features of these units are summarized in Table 1.

KOPE FORMATION. Kope fossil assemblages are characterized by small, thin-shelled brachiopods (Onniella, Sowerbyella) and ramose trepostome bryozoans (Batostoma, Dekayia), and the "lace-collared" trilobite, Cryptolithus. Most slabs to be seen in the creek bed are covered with a single species, such as Onniella or a ramose bryozoan. Preservation ranges from entire, articulated specimens to disarticulated, fragmentary skeletal remains. Kope assemblages appear to have suffered little post-mortem transport and abrasion, although disarticulation and local dispersal are common. Some bryozoan-dominated beds are probably preserved in situ. The Kope environment was a subtidal, open marine setting in which patches of shelly benthos stabilized a muddy substratum. Colonization of the muds was initiated by thin-shelled brachiopods or bryozoans which were followed in succession by forms that required hard or skeletal substrata. Kope assemblages reflect many of the attributes of short-term ecologic succession as defined by Walker and Alberstadt (1975) and recognized elsewhere in the Cincinnatian by Harris and Martin (1979) and in the Kope by Harrison and Mahan (in Meyer et al., 1981).

FAIRVIEW FORMATION. Fairview assemblages are marked by changes in faunal composition and morphologic character. Common Fairview brachiopods such as Rafinesquina alternata, Platystrophia laticosta, and Hebertella sinuata and others are larger and more robust than Kope forms. Ramose trepostome bryozoans are common, but platy, frondose forms such as the typical Constellaria and Heterotrypa are major contributors. Morphologic trends toward greater size, shell thickness and corrugation (Platystrophia) indicate adaptation to increased water movement and shallower depth compared to Kope environments Fossil preservation again ranges across the entire spectrum from complete, articulated specimens, to fragments.

A particularly noteworthy preservational feature in the upper Fairview (as well as higher in the section) are the "shingled" Rafinesquina beds. These beds are formed of imbricated, edgewise shells of this common, thin-shelled concavo-convex strophomenid brachiopod. Because Rafinesquina lived with the commissural plane parallel to the substratum, the edgewise attitude undoubtedly developed post-mortem from wave oscillation. In view of the occurrence of modern edgewise conglomerates in shoalwater depths, the shingled Rafinesquina beds may be one of the strongest indicators of extremely shallow water conditions during Cincinnatian time.

GRANT LAKE LIMESTONE (BELLEVUE MEMBER). With its marked reduction in shale content, the Bellevue is largely composed of closely packed brachiopods and bryozoans. The trend toward larger size and robust character reaches a maximum in the Bellevue, with large Rafinesquina, Hebertella sinuata, and Platystrophia ponderosa dominating the brachiopods. The Bellevue offers the epitome of Cincinnatian trepostome bryozoan development, with thick frondose and massive morphotypes such as Heterotrypa forming entire layers. Bellevue trepostomes were monographed by Singh (1979). Abrasion, breakage, and particularly encrustation are common preservational features in the Bellevue that indicate reworking and shifting of shell material by water movement in probably very shallow water.

TRACE FOSSILS

The Cincinnatian Series is rich in fascinating trace fossils. Although Osgood's (1970, 1977) comprehensive analyses of the morphology and taxonomy of Cincinnatian trace fossils provide an excellent foundation for application of ichnology to Cincinnatian paleoenvironmental interpretation, very little has been done in this regard. Certain types of trace fossils are superbly displayed in Backbone Creek and these will be discussed briefly.

U-TUBES. "U-tubes" are U-shaped vertical burrows that represent the dwelling structure of an infaunal suspension-feeding organism. Modern invertebrates that form U-tubes include polychaetes, hemichordates (acorn worms), and other worm groups. The basic structure of a U-tube is shown in Fig. 8. The "arms" represent the final dwelling tube of the organism while the spreiten represent traces of the base of former U-tubes occupied as the organism burrowed. Spreiten occurring only between the arms are termed PROTRUSIVE and indicate an organism burrowing deeper with time. Spreiten occurring below the base of the U are termed RETRUSIVE and indicate an organism adjusting the position of its burrow upward with respect to the sediment-water interface. Under the assumption that the organism preferred a constant burrow depth below the sediment-water interface, protrusive spreiten indicate erosive conditions and retrusive spreiten indicate sediment deposition. An alternative interpretation of protrusive spreiten is that the organism simply burrowed deeper as it grew. Figs. 9 and 10 illustrate varieties of U-tubes found in the Cincinnatian. All have protrusive spreiten. According to Osgood (1970, 1977), the organism(s) responsible for these U-tubes cannot be identified. U-tubes present an entirely different aspect if seen in horizontal section or on a bedding surface. A common form is the "dumbbell", which was interpreted by Osgood as shown in Fig. 10.

Chondrites. Another common trace fossil at Backbone Creek is *Chondrites*. *Chondrites* represents a branching burrow system radiating from a few major tubes (Fig. 11). The tracemaker was an infaunal deposit feeder of uncertain affinities. Osgood (1970) recognized three forms of *Chondrites* in the Cincinnatian (Fig. 11). Type-A appears as a *vertically* elongated dendritic system or as a circular cluster of holes on a bedding plane. Type-B occurs as a "loose grouping of tunnels piercing the bedding planes", and in vertical section "as a series of tunnels intersecting the vertical plane at various attitudes" (Osgood, 1970). Type-C is a dense network of interwoven tubes occurring as concave epireliefs (Osgood, 1970). Types-A and B should be observable at Backbone Creek, but Type-C is restricted to Richmondian strata according to Osgood.

CINCINNATIAN ICHNOFACIES. Fig. 12 illustrates the diversity of trace fossils found in the Cincinnatian, grouped according to their behavioral classification. Osgood's (1970) analysis of the composite trace fossil assemblage of the Cincinnatian indicates that it belongs to the *Cruziana* ichnofacies of shallow-water origin (<35 m depth). This conclusion is based on the dominance of temporary resting traces (CUBICHNIA), deposit-feeding traces (FODINICHNIA), and dwelling traces (DOMICHNIA) over grazing traces (PASCICHNIA). Tobin (1982) recognized elements of the *Skolithos* ichnofacies as well as the *Cruziana* ichnofacies (Table 1), substantiating the shallow-water nature of Cincinnatian environments.

Osgood noted that certain trace fossil subassociations may occur in the Cincinnatian but remain largely unstudied. In particular Osgood mentioned the common occurrence of *Diplocraterion*, *Chondrites*, and *Trichophycus* in the same bed. You should examine the *Diplocraterion* horizons at Backbone Creek for evidence of this association. Further study of Cincinnatian trace fossils could provide considerable new paleoenvironmental information.

STREAM ANTICLINES

Localized upwarps, or stream anticlines, often occur in the interbedded limestone and shale of the Cincinnatian Series and can be found in Backbone Creek. These upwarps are limited to a few meters in width and reach as much as 45 m (150 ft) in length, but do not affect overlying and underlying beds structurally. The axes of these stream anticlines often parallel the stream valley but can have other orientations. A cross-sectional view of a typical stream anticline can be observed in Backbone Creek.

Stream anticlines appear to be restricted to bedrock that is interbedded with soft shale (Simmons, 1966). Differential pressure between the stream valley and the adjacent hillsides is believed to cause the shale to move plastically toward the valley. The increased volume of shale results in the upwarp of the limestones. In addition, expansion of water-absorbent clay minerals in the shale may be a source of pressure. Stream anticlines appear to be restricted to stream valleys and are believed to form during the process of stream erosion. Direct observation of stream anticline formation confirms the time of formation (Shaler, 1877).

GEOMORPHOLOGY

Cincinnatian Series terranes in southwestern Ohio generally do not exhibit prominent geomorphic features. The thick sequence of interbedded limestone and shale allows little opportunity for a distinct ledge or steep slope to form. However, some good examples of subtle geomorphic features are present within Backbone Creek.

Traversing upstream in Backbone Creek the valley becomes narrow and steep as the Kope-Fairview formational contact is approached. The higher ratio of limestone to shale in the Fairview (50-50) compared to the Kope (30-70) causes the overlying Fairview to form resistant hilltops which support the steep valley walls. Farther upstream in the Fairview the valley again widens and waterfalls are common over the resistant limestones.

Many recent slump features can be observed along the valley sides. The combination of shale-rich soils weathering from the bedrock (mainly Kope) and the steep topography creates prime conditions for landslides. Water percolating through the soil reaches the impermeable soil-bedrock interface and flows along this surface. The heavy water-saturated soil becomes unstable (particularly in the Spring) and slides as flows along the lubricated soil-bedrock interface. This type of landsliding poses a major engineering problem in Hamilton and Clermont counties, causing millions of dollars in damage, repairs, and prevention annually.

GLACIAL GEOLOGY

Southwestern Ohio experienced several glacial episodes each depositing separate sediment layers. Several erosional episodes dissected these sediments and the underlying bedrock causing several drainage patterns to be superimposed on one another. The present topography is a complex assemblage of abandoned sediment-filled valleys which may or may not coincide with present drainage.

The last major exposure to be seen on the field trip is an outcrop of glacial sediments that appears randomly placed. However, additional mapping in adjacent streams to the north revealed similar zones of glacial material. These glacial outcrops appear to align in a northwest orientation and may represent an earlier stream valley, now buried by Pleistocene glacial material.

ROAD LOG

We will meet at Backbone Creek at 9:00 a.m. on Sunday, April 21. The road log below will take you from the University of Cincinnati campus to the starting point for the field trip at Backbone Creek. Driving time is about 45 minutes.

Total	Increment	
	0.0	Corner of Clifton Ave. and St. Clair Street at NW corner of University of Cincinnati campus. Proceed WEST at this intersection and BEAR RIGHT onto the Dixmyth Ave. connector.
0.9	0.9	Proceed straight at intersection of Dixmyth and Central Parkway.
1.0	0.1	Merge into right lane and enter ramp for I-75 SOUTH. Proceed SOUTH on I-75. You are travelling in the Mill Creek Valley. This valley contained the north-flowing preglacial, Teays-age Licking River and later the north-flowing Deep Stage of the Ohio River. Today Mill Creek flows south to the Ohio River on valley-fill sediments up to 45 m (150 ft) thick. Merge to left lane when you see signs for downtown Cincinnati.
4.4	3.4	Take exit 1-A (Downtown Cincinnati sign), Fort Washington Way.
5.2	0.8	Take exit 1-K (sign for Columbia Parkway); KEEP RIGHT.
5.6	0.4	Take exit 1-J for I-471 SOUTH, cross Ohio River on the Dan Beard ("Golden Arches") Bridge. Enter Kentucky and proceed SOUTH on I-471.
7.5	1.9	Roadcut on left is Kope and lower Fairview Fms.; outcrops on right are Kope.
9.0	1.5	Roadcut on right shows Kope-Fairview contact.
9.4	0.4	Roadcuts in Kope on both sides.
9.8	0.4	Merge to left lane to prepare for I-275 EAST interchange. Kope roadcut on left.

10.4	0.6	Take exit 1-A, I-275 EAST. Fairview in roadcut on ramp.
11.3	0.9	Roadcuts on both sides approaching Ohio River bridge are Fairview followed by Kope below.
12.3	1.0	Ohio River bridge takes you back into Ohio. Proceed NE on I-275 to exit 63-B, for Batavia, Rte. 32.
15.0	2.7	Kope in roadcut on left.
20.9	5.9	Beechmont Ave. interchange; DO NOT EXIT.
23.1	2.2	EXIT at 63-B, Batavia. Proceed EAST on Ohio Rte. 32.
28.0	4.9	Roadcut as you descend hill exposes Bellevue followed by Fairview below. DO NOT EXIT AT BATAVIA.
29.2	1.2	Cross bridge over East Fork, Little Miami River. Shortly after crossing bridge EXIT for Owensville, Rte. 222-132. Turn RIGHT (NORTH) onto 222.
29.5	0.3	Turn RIGHT (EAST) onto Rte. 132. DO NOT TAKE RTE. 32 ENTRANCE RAMP.
29.9	0.4	Turn RIGHT onto narrow paved road JUST PAST Rte. 32 entrance ramp.
30.1	0.2	Park along side of this dead end road. Backbone Creek is on the right. We will hike upstream from here. Vans will return you to this point from the end of the traverse.

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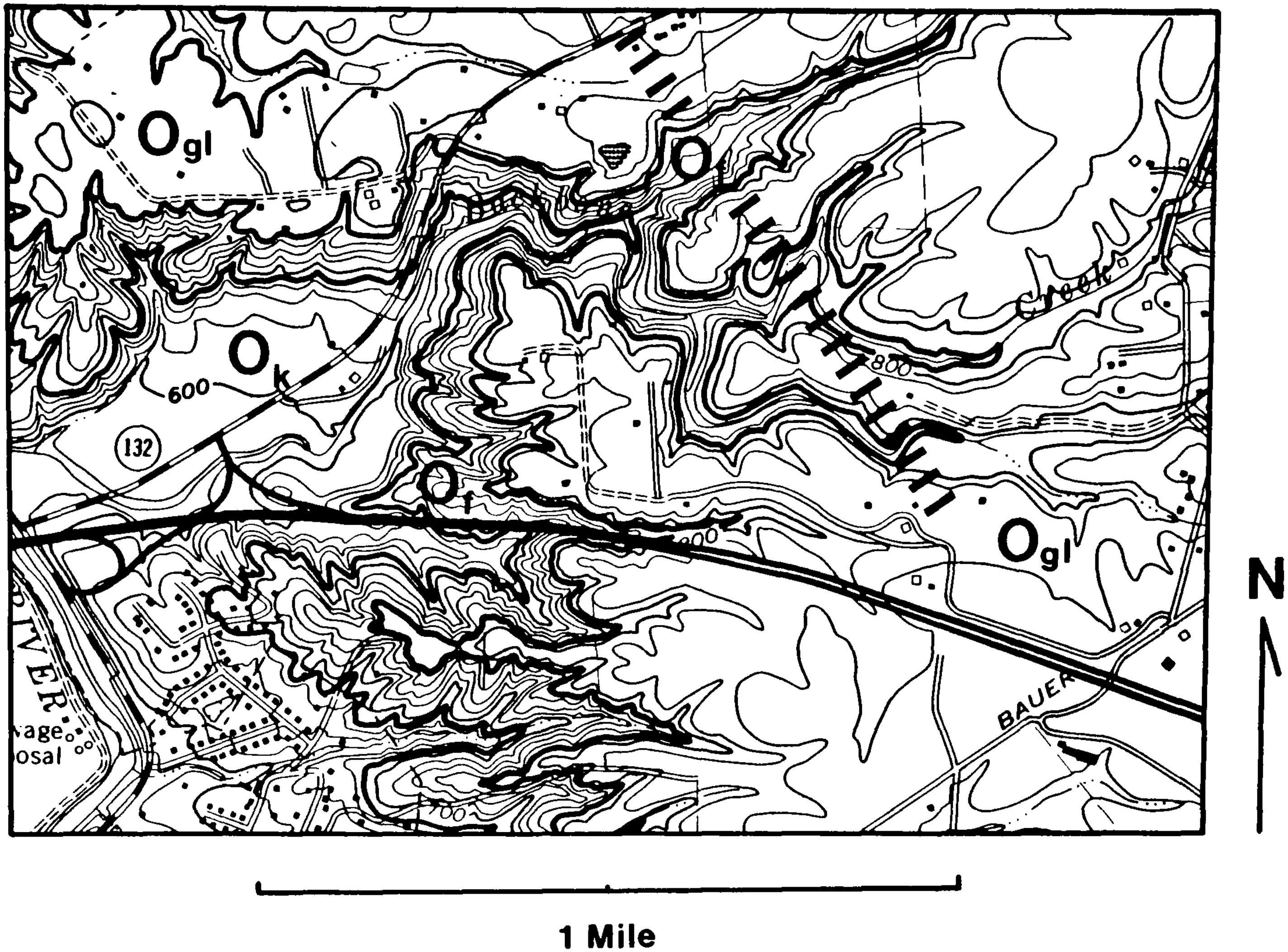


Figure 1: Bedrock Geologic Map of the Backbone Creek Area. Ok = Kope Formation, Of = Fairview Formation, Ogl = Grant Lake Limestone. Barred line marks trace of glacial sediment filled valley.

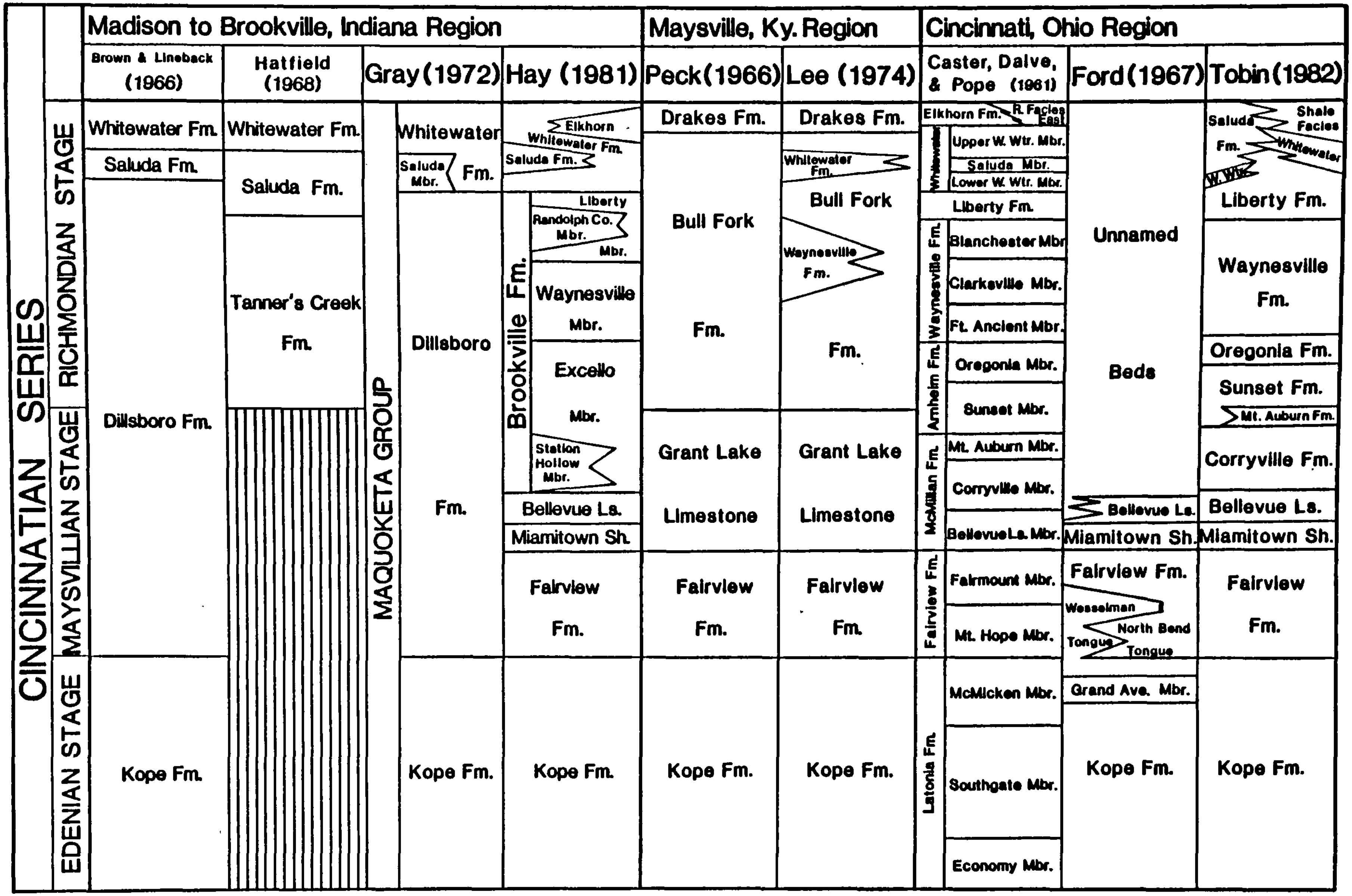


Figure 2: Development of Cincinnatian Stratigraphic Nomenclature after 1960. (From: Schumacher, 1984)

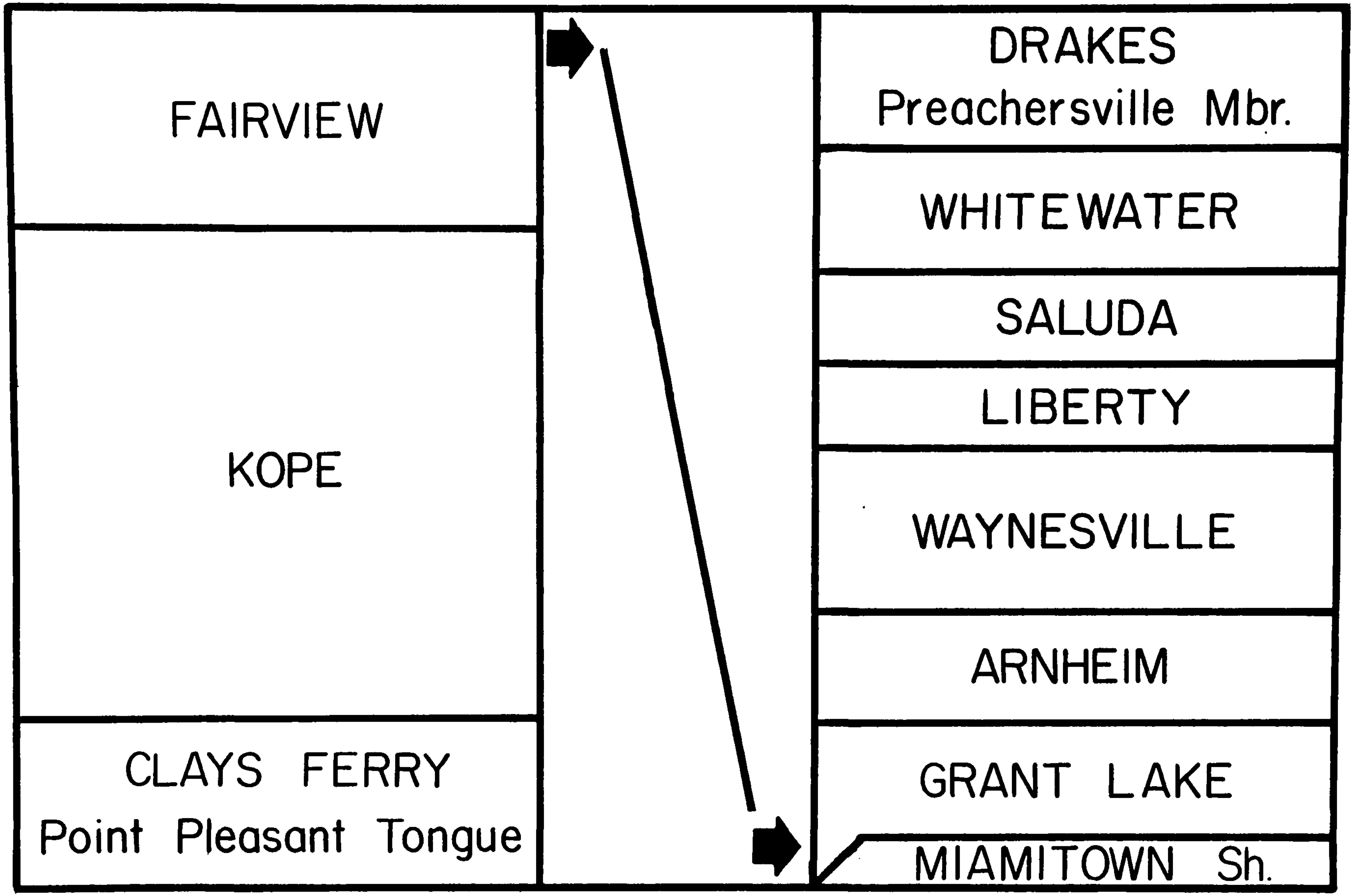


Figure 3: Stratigraphic Nomenclature adopted by the Ohio Division of Geological Survey Mapping Program

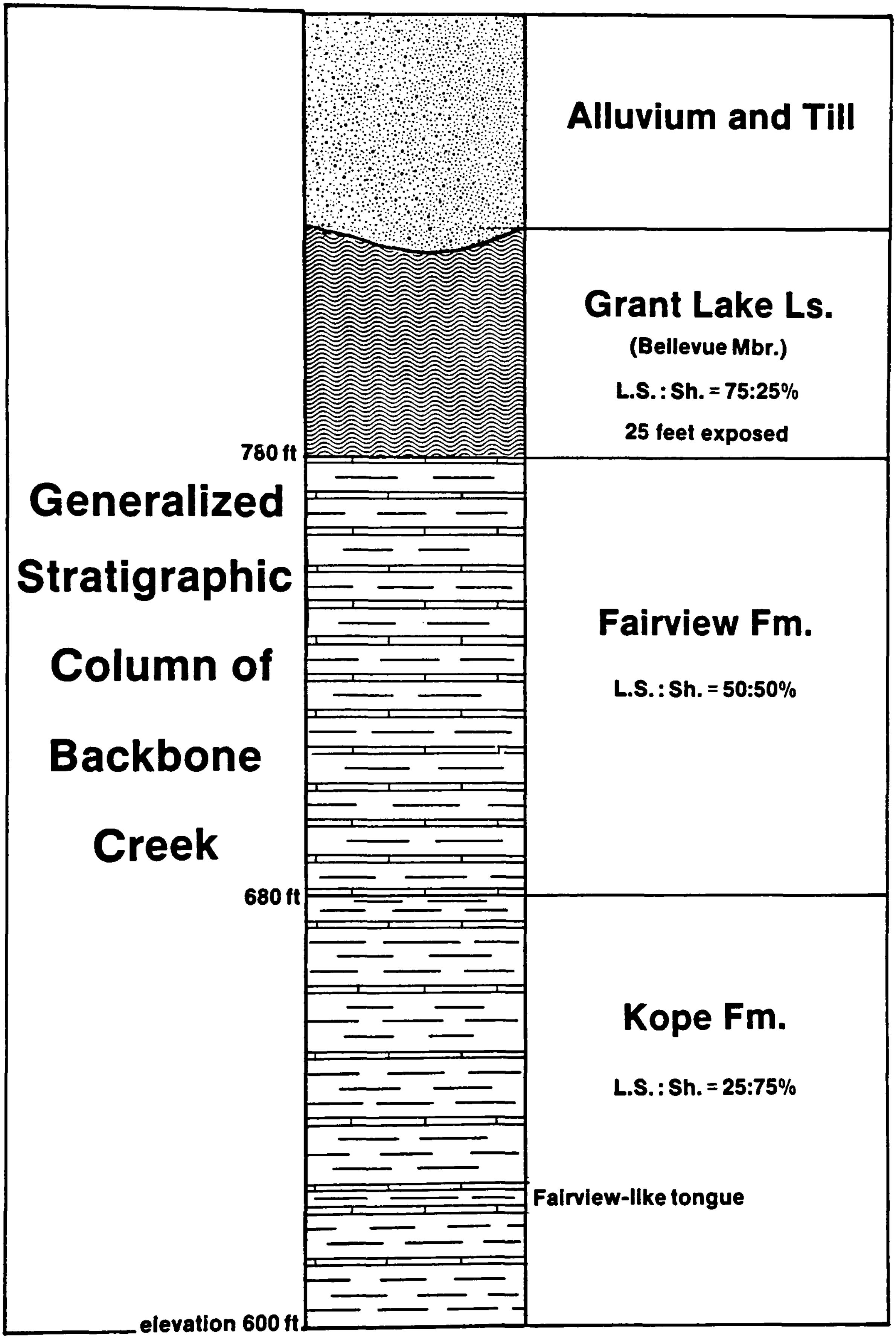

Alluvium and Till
Grant Lake Ls.
(Bellevue Mbr.)
L.S. : Sh. = 75:25%
25 feet exposed
780 ft
Generalized Stratigraphic Column of Backbone Creek
Fairview Fm.
L.S. : Sh. = 50:50%
680 ft
Kope Fm.
L.S. : Sh. = 25:75%
Fairview-like tongue
elevation 600 ft

Figure 4

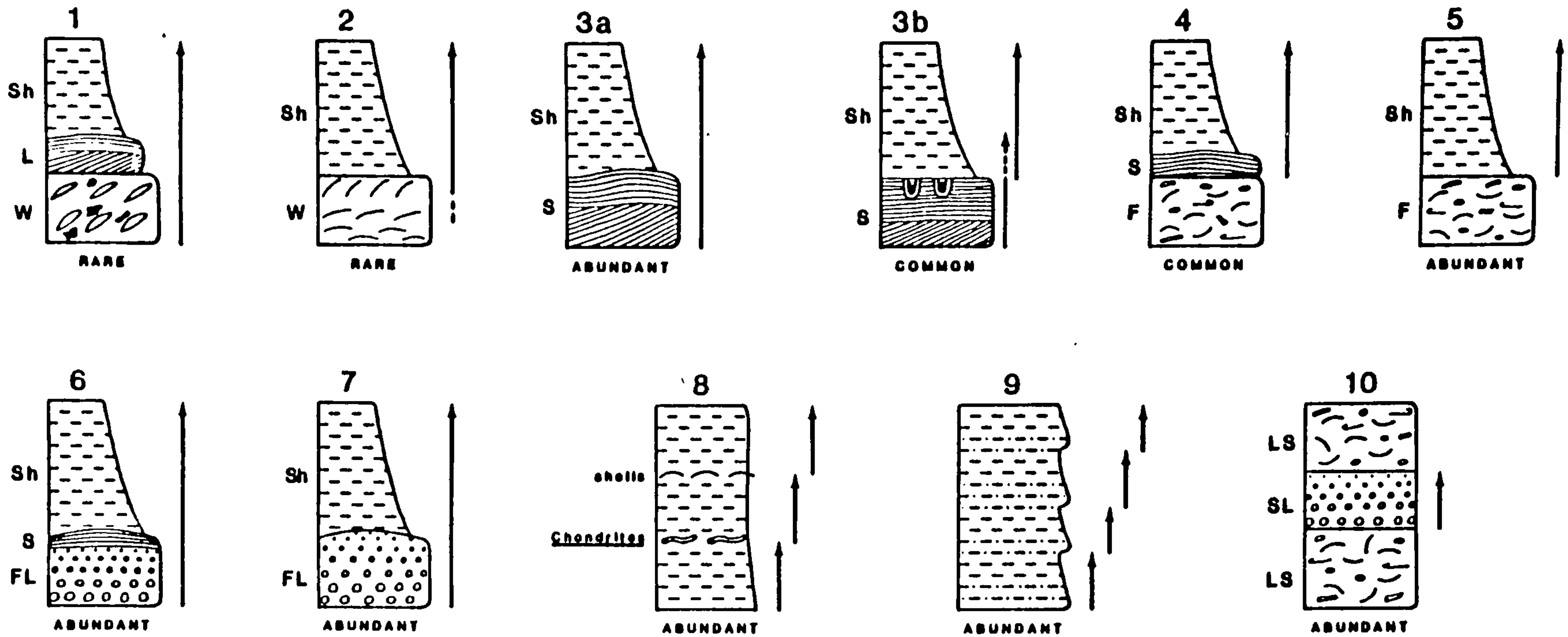
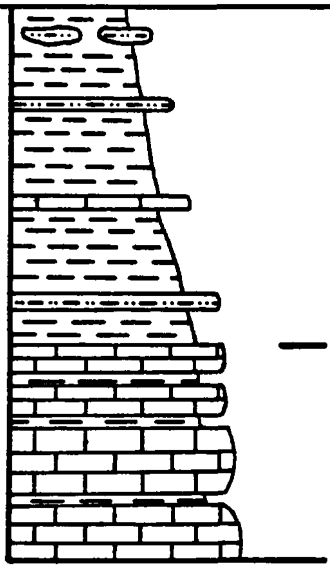


Figure 5: Common Varieties of Cincinnatian Storm Cycles. Arrows denote layers of sediment which were deposited by single storm events. Sh= Shale, L= laminated unit, W= whole fossil packstone or grainstone, S= siltstone, FL= fine limestone (bioclasts less than 2 mm), F= fragmental limestone, SL= storm layer, LS= limestone (modified from Tobin, 1982).



SHALE HEMICYCLE:

Relatively thin, wavy to nodular beds, (calcisiltites, micstones, and siltstones) and thick shale beds. Shales are generally Shales are generally barren of fossils except in thin fossiliferous horizons.

CARBONATE HEMICYCLE:

Relatively thick, planar bedded, closely spaced limestones with thin shale interbeds. Matrix-poor, well-sorted, medium to fine grained, with a high degree of fossil breakage.

Figure 6: Characteristics of Cincinnatian Megacycles (after Tobin, 1982)

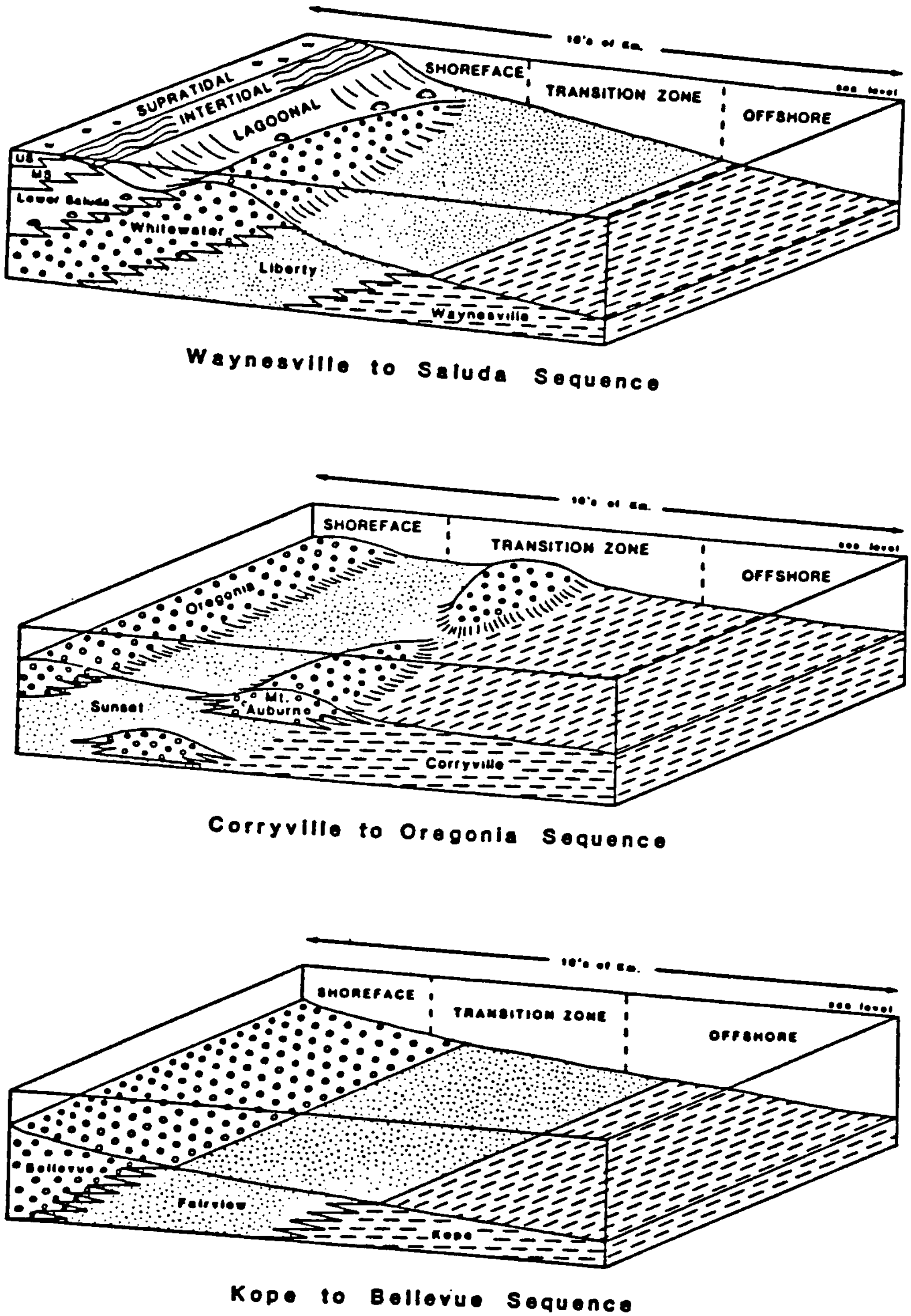


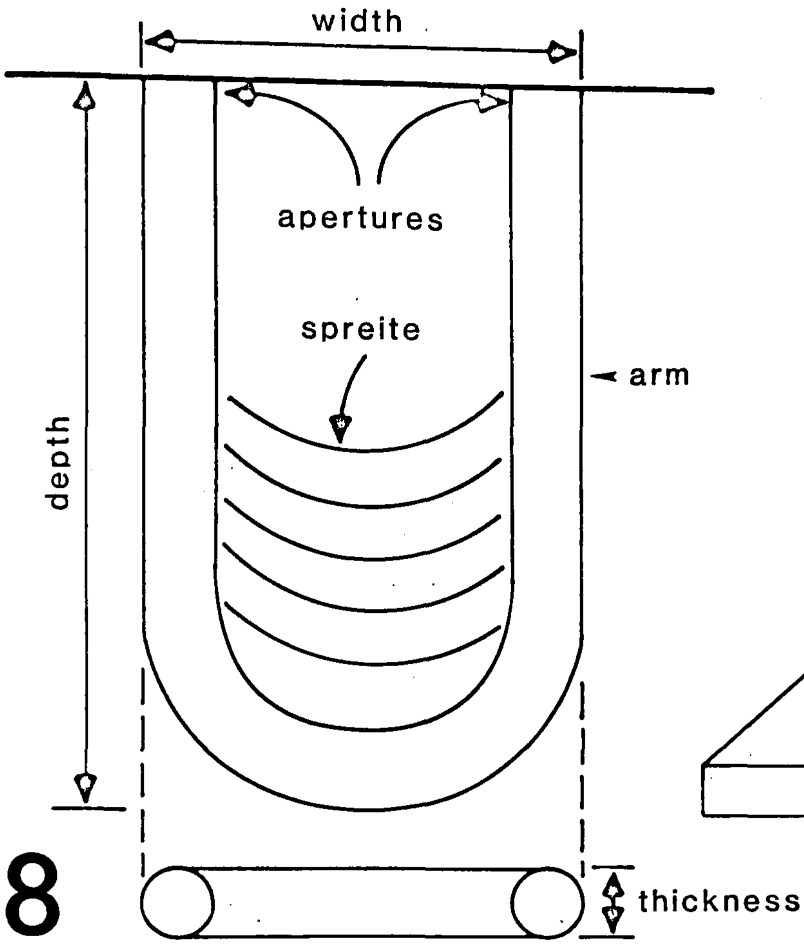
Figure 7: Major shoaling sedimentary cycles from the Cincinnatian Series (modified from Tobin, 1982, fig. 75).

FIGURE 8. BASIC STRUCTURE AND TERMINOLOGY OF A U-TUBE. FROM FÜRSICH, 1974.

FIGURE 9. THREE FORMS OF THE U-TUBE DIPLOCRATERION FROM THE CINCINNATIAN. NOTE BASAL EXPANSIONS. FROM OSGOOD, 1970.

FIGURE 10. RECONSTRUCTION OF DIPLOCRATERION BICLAVATUM (MILLER). BASE OF U LIES WITHIN SILTSTONE; MOST OF TUBE IS WITHIN SHALE. SCALE = 1 CM. FROM OSGOOD, 1977.

FIGURE 11. TWO RECONSTRUCTIONS OF CHONDRITES. FROM HÄNTZSCHEL, 1975.



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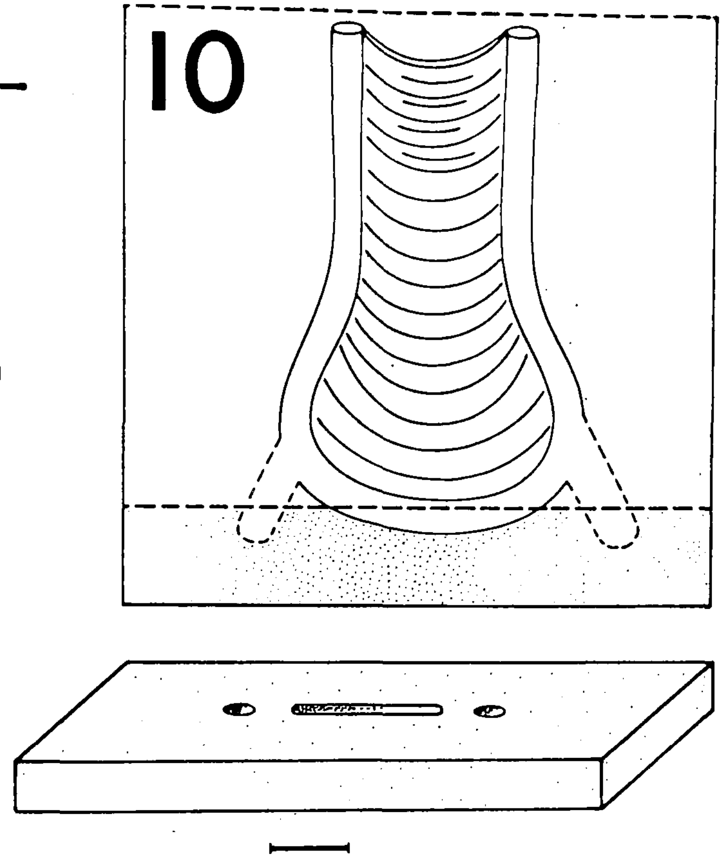

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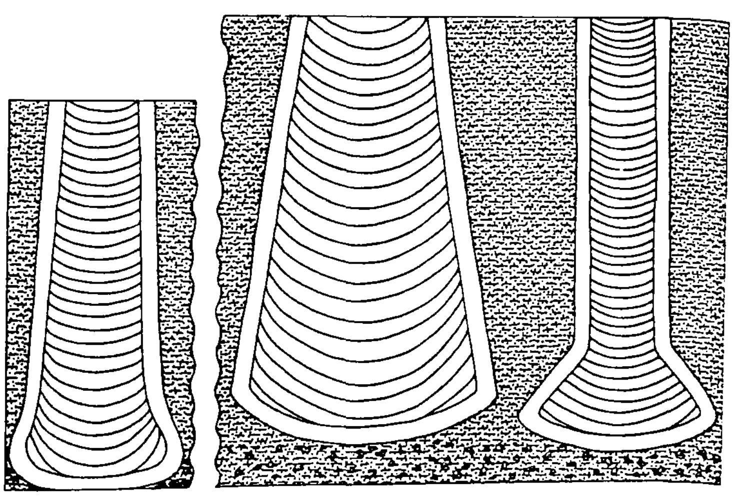

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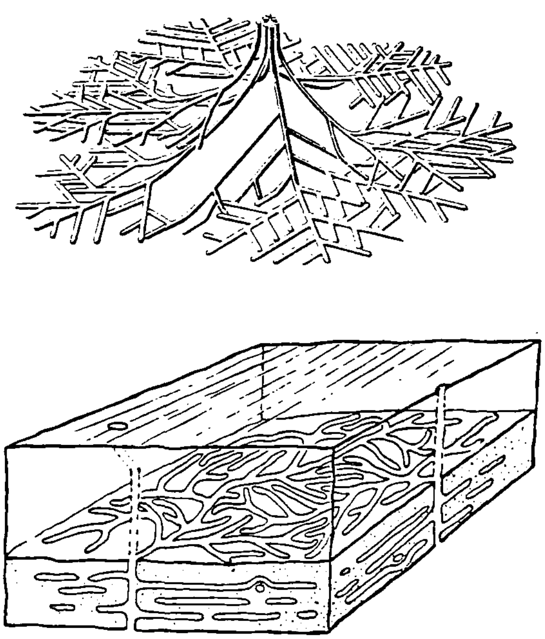

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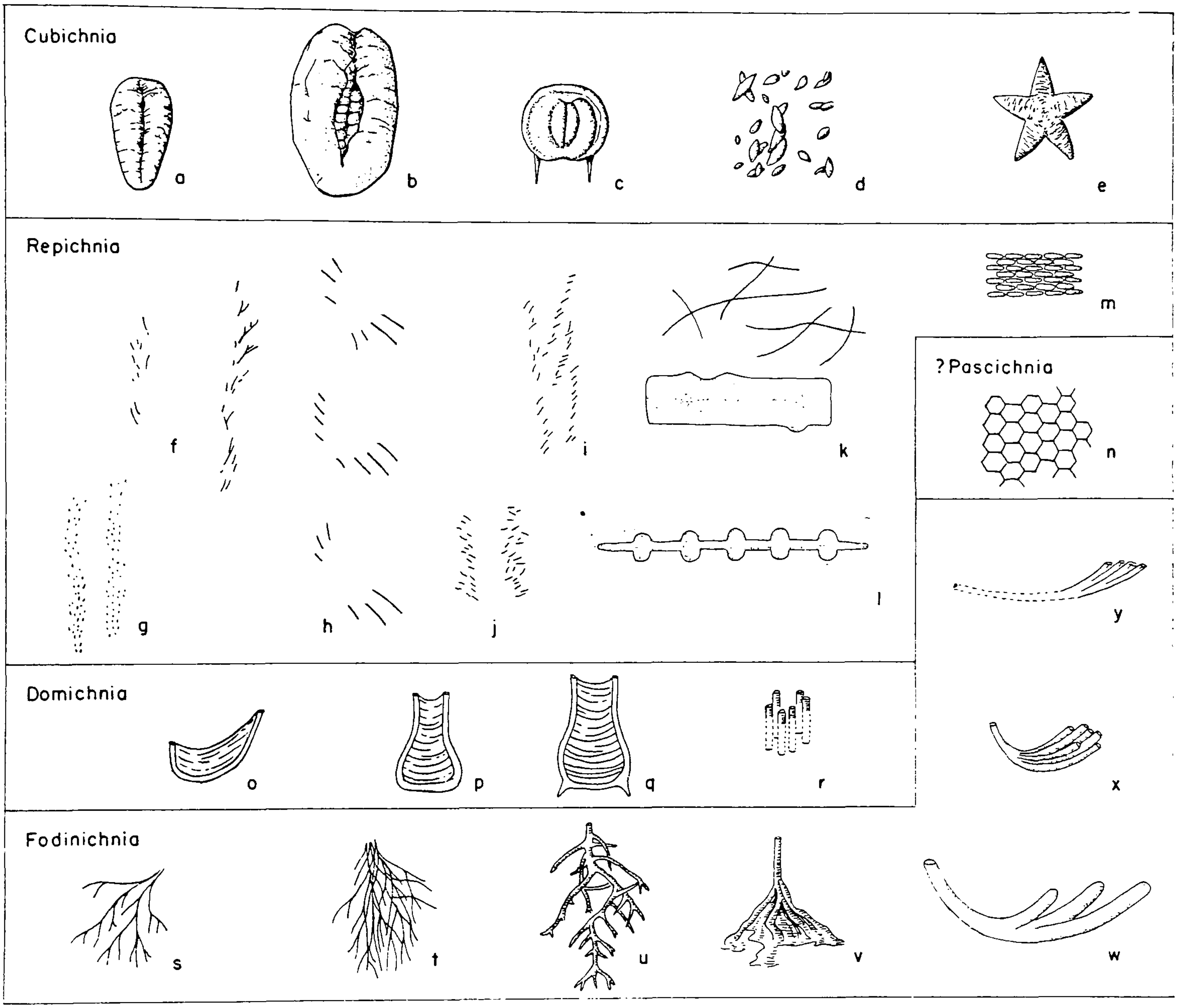


Text-figure 29. — Cincinnatian Trace Fossil Suite. The chart shows reconstruction of Cincinnatian trace fossils placed in their ethologic categories. Cubichnia are numerous both in kind and numbers whereas the only Pascichnia are two specimens tentatively assigned to *Paleodictyon*. This distribution places the Cincinnatian within Seilacher's "*Cruziana* facies," *i.e.*, a shallow water, marine environment.

a. *Rusophycus pudicum* (X 0.5); b. *Rusophycus carleyi* (X 0.25); c. *Rusophycus cryptolithi* (X 1); d. *Lockeia siliquaria* (X 0.5); e. *Asteriacites stelliforme* (X 0.3); f. *Asaphoidichnus trifidum* (X 0.25); g. *Trachomatichnus numerosum* (X 0.25); h. *Allocotichnus dyeri* (X 0.3); i. cf. *Petalichnus multipartitum;* oblique movement (X 0.5); j. cf. *Petalichnus multipartitum;* straight-ahead movement (X 0.5); k. *Palaeophycus* sp.; plan and cross-section views (X 0.3); l. *Rhabdoglyphus* sp. (X 0.5); m. *Tylichnus asperum* (X 4); n. ?*Paleodictyon* sp. (X 1); o. *Corophioides* cf. *luniformis* (X 0.2); p. *Corophioides cincinnatiensis* (X 0.2); q. *Corophioides biclavata* (X 0.2); r. *Skolithos delicatulus* (X 0.5); s. *Chondrites*, type-B (X 0.2); t. *Chondrites*, type-C (X 0.25); u. *Chondrites*, type-A (X 0.25); v. *Fascifodina floweri* (X 0.2); w. *Trichophycus venosum* (X 0.15); x. *Phycodes flabellum* (X 0.25); y. *Dactylophycus quadripartitum* (X 0.25)

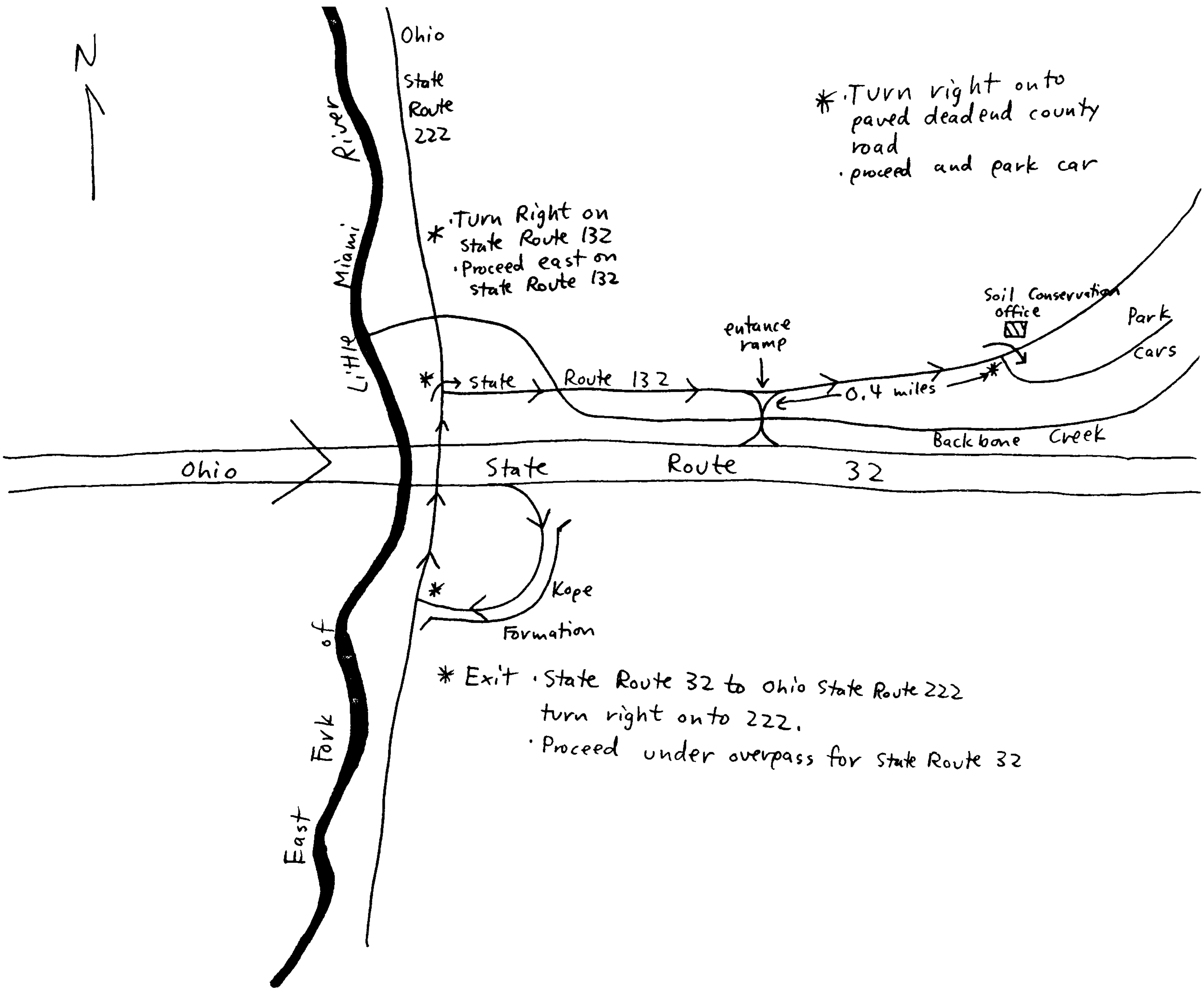
FIGURE 12. CINCINNATIAN TRACE FOSSIL ASSEMBLAGE. FROM OSGOOD, 1970.

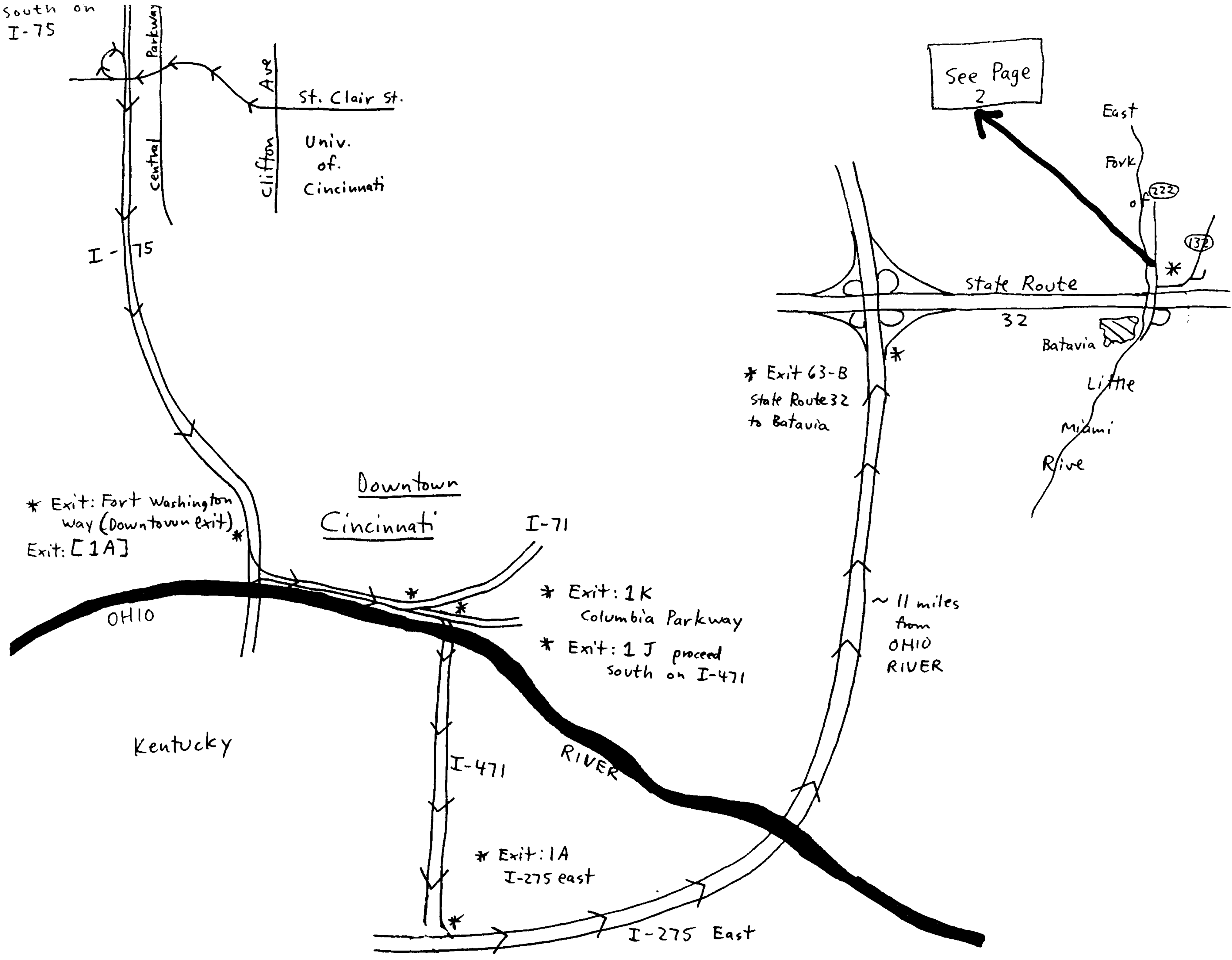
TOBIN, 1982

FORMATION	DIVERSITY		DOMINANT FOSSIL ASSEMBLAGE	BRACHIOPOD MORPHOLOGY	BRYOZOAN MORPHOLOGY	FOSSIL PRESERVATION	ICHNO-FACIES
	Generic	Petro-graphic					
BELLEVUE	4.7	7.0	brachiopods bryozoans crinoids trilobites (open marine)	Large, rounded, thick shells with coarse ornamentation (Platystrophia, Hebertella) Some large, wide, flat shells (Rafinesquina)	Thick, massive lumps or fans (Monticulipora) Thick branching forms (Hallopora)	Micritization, bryozoan and algal encrustation, boring, abrasion	Mixed Skolithos/ Cruziana
MIAMITOWN	2.0	2.0	gastropods pelecypods brachiopods (restricted marine)	Large, wide, flat shells (Rafinesquina) Some large, rounded shells with coarse ornamentation (Platystrophia, Hebertella)	Not applicable	Well preserved; some bryozoan encrustation	Skolithos
FAIRVIEW	4.9	6.5	brachiopods bryozoans trilobites crinoids pelecypods gastropods (open marine)	Large, wide, flat shells (Rafinesquina, Strophomena, Zygospira) Some large, rounded shells (Platystrophia, Hebertella, Plectorthis)	Small, delicate, branching forms (Hallopora, Dekayia, Escharopora) Some large, robust, branch-forms (Constellaria, Heterotrypa, Homotrypa)	Well preserved; some boring and bryozoan encrustation	Cruziana
KOPE	4.8	7.0	brachiopods bryozoans trilobites crinoids pelecypods gastropods (open marine)	Small, thin shelled, flat, and finely ornamented (Onniella, Sowerbyella, Zygospira)	Small, delicate, branching forms (Hallopora, Batostoma, Dekayia)	Well preserved; some bryozoan encrustation	Cruziana

Autecological comparison of rock facies in the Kope to Bellevue shoaling-upward sequence.

TABLE 1.


N
Ohio State Route 222
Little Miami River
East Fork of
* ·Turn Right on state Route 132
·Proceed east on state Route 132
state Route 132
entance ramp
0.4 miles
Soil Conservation office
Park cars
* ·Turn right onto paved deadend county road
·proceed and park car
Backbone Creek
Ohio State Route 32
Kope Formation
* Exit ·State Route 32 to Ohio State Route 222 turn right onto 222.
·Proceed under overpass for State Route 32


South on I-75
Parkway
Central
Ave
Clifton
St. Clair St.
Univ. of. Cincinnati
I-75
See Page 2
East Fork of Little Miami River
222
132
State Route 32
Batavia
* Exit 63-B State Route 32 to Batavia
Downtown Cincinnati
* Exit: Fort Washington way (Downtown exit) Exit: [1A]
I-71
* Exit: 1K Columbia Parkway
* Exit: 1 J proceed south on I-471
~ 11 miles from OHIO RIVER
OHIO
RIVER
Kentucky
I-471
* Exit: 1A I-275 east
I-275 East

BACKBONE CREEK: NUMBERED STATIONS

The following stations are marked in yellow paint along the traverse and serve as rallying points where the leaders will discuss some aspects of the geology. Other points of interest are indicated by yellow arrows along the way.

1. Kope Formation: typical lithology, bedding, sedimentary features include starved ripples and evidence of storm processes.

2. Two loose slabs with oriented nautiloid cephalopods; these are commonly found but little is known about their in situ orientation.

3. Loose slab next to one of the nautiloid slabs showing rip-up clasts, a possible indicator of storm processes.

4. A prominent rippled bed 15-20 cm thick with *Onniella* fragments, clasts. *Diplocraterion* trace fossils in siltstone above.

5. Landslide on N side producing major deadfall across the stream. Excellent demonstration of landslide features.

6. Fossiliferous ledge on S side about 4 m upstream from deadfall: note trilobite fragments of *Cryptolithus*, *Isotelus*, *Flexicalymene*, also pinch and swell of bed, and ramose bryozoan colony in shale just above ledge. Bryozoan possibly in growth position but smothered by influx of mud during rapid deposition.

7. Prominent iron staining on banks along N side; note pyrite on slab suggesting source. Major ledge here about 30 cm thick with flat but pitted upper surface may represent hardground. Overlying it are layers rich in ramose bryozoans that could have been living on the stabilized substratum of the hardground.

8. Pair of rippled beds with in place nautiloid just below, S side. Arrow-marked slab just upstream shows excellent bryozoan assemblage.

9. Wet, dripping ledge on N side with ramose bryozoan colonies possibly in growth position. Note increase in limestone in beds above marking tongue of Fairview-like lithology within Kope Fm. Arrow-marked slab on S side shows excellent horizontal burrows.

10. N side, Fairview-like lithology now closer to stream level: note slabs replete with *Onniella*, some *Rafinesquina*, and rippled surfaces.

11. S side opposite 10: Recent imbricated stream debris overlying Ordovician bedrock.

12. Large rippled slab on S side showing graded bedding; what kind of sedimentary processes produce this type of rippling?

13. "Fossil" stream anticline in bank on S side; note imbricated debris above similar to that seen in present stream bed.

14. High bank on S side: increase in limestone content is a major feature of large-scale shoaling-upward cycles in the Cincinnatian. Large rippled slab just upstream from 14 shows bedding plane aspect of *Chondrites* and *Diplocraterion* trace fossils.

15. "*Diplocraterion* Falls": upper Kope Fm., a shale falls held up by calcisiltstone beds replete with the U-tube *Diplocraterion*. Similar U-tube horizons are known in the upper Kope in northern Kentucky. Note sinuous gutter casts in stream bed layers just above falls.

16. Kope/Fairview contact.

17. "Fairview Falls": capping bed has a peculiar chaotic aspect. Arrow-marked slab in stream with typical Fairview bryozoan *Constellaria*; note increase in frondose bryozoans, *Rafinesquina* brachiopods.

18. High bank in Fairview, S side: typical lithology, bedding. Shingled *Rafinesquina* slab opposite 18 on N side (see guidebook).

19. Fairview/Bellevue contact: note typical Bellevue lithology, bedding, and fossils.

20. Buried Quaternary stream valley (see guidebook).